QUARTZ-FELDSPAR-PORPHYRY (GRANIPHYRO LIPAROSE-ALASKOSE) FROM LLANO, TEXAS.

THERE occurs in the vicinity of Llano, Tex., a porphyry which is very interesting petrographically, and may prove equally so commercially. It forms a large body whose shape and geological occurrence have not yet been described. It is said to be quite uniform in character. The material submitted by Dr. William B. Phillips, Director of the University of Texas Mineral Survey, for petrographical study is a gray porphyry with abundant phenocrysts of red feldspar and blue quartz, the matrix or groundmass being aphanitic to phanerocrystalline. It appears to have a crystalline texture, but the individual grains are not distinctly visible without a microscope. The rock is therefore mottled red and gray, with light blue spots of opalescent quartz.

The phenocrysts vary in size, the largest feldspars being 10^{mm} in diameter, the largest quartzes 5^{mm}. The quartzes exhibit a beautiful blue color, which is light sky-blue in the central part of the crystal and dark at the margin. The crystals are not all colored to the same degree; some are lighter than others. The color does not change perceptibly with a change in the angle of incidence, or in the position of observation, except that in certain positions there is a brilliant light blue luster. The feldspars are rather uniformly colored light Indian-red, the larger crystals being mottled with gray.

The proportion of phenocrysts and groundmass estimated from the surface of the specimen and from three thin sections is:

Phenocrysts	quartz	10.7
	feldspar	26.5
Groundmass		62.8
		100.00

Under the microscope the groundmass is seen to be holocrystalline and microcrystalline, and is composed of feldspar and quartz in nearly equal proportions, together with a small amount of brownish-green mica, and still less fluorite, magnetite, apatite, and zircon.

The proportions in which these occur was determined by microscopical measurement to be approximately, in 62.8 per cent. of groundmass:

		Total
Quartz,	23.9	34.6
Feldspar,	29.2	55.7
Biotite,	8.6	8.6
Fluorite,	1.0	1.0
Apatite,	0.13	0.13
	62.83	100.03

The fabric of the groundmass is uniformly heterogeneous, being a mixture of automorphic granular and micrographic. It consists of anhedrons of quartz, very free from inclusions, except some minute gas cavities, with similarly shaped anhedrons of microcline slightly clouded with alteration products, besides anhedrons of twinned albite with an approach to automorphism. These anhedrons vary in size from 0.1 to 0.01^{mm} in diameter. Throughout the whole are scattered at short intervals granular clusters of graphic intergrowth of quartz and feldspar. The crystallization of the graphic parts was almost contemporaneous with that of the anhedrons, as these are developed in continuous orientation with the graphic clusters.

The mica is xenomorphic in great part, and is in about the same sized anhedrons as the quartz and feldspar. It appears to have been almost contemporaneous in crystallization with these minerals. Its color is green to brownish-green.

Fluorite occurs in irregularly shaped anhedrons, xenomorphic in form. It is colorless in thin sections, exhibits distinct cleavage, and is characterized by its low refraction and isotropic behavior. It is quite uniformly scattered through the groundmass.

Apatite occurs in colorless microscopic prisms. Magnetite and zircon both occur in anhedrons in such small quantities that they were not measured. They appear to constitute a small fraction of 1 per cent. of the rock.

A careful study of the feldspars in the groundmass showed that microcline and albite are present in nearly equal proportions, and that they form separate and distinct crystals not perthitically intergrown.

The feldspar phenocrysts are microcline, with extremely minute and regular multiple twinning in two directions. The delicacy of the twinning suggests a possible soda content in the potash feldspar approaching soda microcline. There is also a perthitic inclusion of albite in irregularly shaped shreds, and also a slight clouding due to alteration, which is probably kaolin with hydrous oxide of iron which gives color to the feldspar.

The quartz phenocrysts contain multitudes of minute inclusions, rather evenly distributed through each crystal, except for a margin of nearly pure quartz in some cases. The inclusions are of two kinds, generally intermingled: one consists of extremely thin, colorless prisms, sometimes passing into lines of minute grains, like broken prisms; the other kind is in equally thin tabular crystals with six sides and trigonal shapes, and a light brown color. The colorless prisms have higher refraction than quartz, but the double refraction is not recognizable. They resemble apatite rather than rutile, having lower refraction than rutile and not being so long as rutile needles often are. The width of these prisms varies from 0.000800^{mm} to much less; that is, it is mostly a fraction of a wave-length of light. The brownish tabular crystals are equally thin, and range in diameter from 0.004^{mm} to much less. Studied by incident sunlight, they exhibit metallic reflections of a bluish-white and also of other colors. They have the crystal form and color of ilmenite.

These inclusions lie at all angles within the quartz crystals, but there appear to be sets of parallel directions intersecting at various angles, so that in some positions many tabular microlites reflect light in one direction. The same is true of the colorless needles. They lie in parallel lines crossing at various angles, whose orientation with respect to the inclosing quartz does not appear to be definite.

The sky-blue opalescent color of the quartz phenocrysts is undoubtedly due to reflection of blue light-waves from the minute colorless prisms, whose width is a fraction of the length of light-waves. It is similar to the blue color of the sky. It is probable, however, that there is also blue light produced by interference of the light reflected from both sides of the minute tabular crystals, whose thickness is also of the order of a fraction of a light wave-length; so that both kinds of phenomena occur within these quartzes.

From the microscopical measurements of the minerals and the optical characters of the feldspars it is possible to estimate approximately the chemical composition of the rock. The feldspars appear to be albite and orthoclase (potash microcline) in almost equal proportions in the groundmass, and the phenocrysts appear to have these molecules in nearly the same proportions. In assuming a chemical compositon for the brownish-green mica, the analysis of that in the soda granite (grano-liparose) of Cape Ann, Mass.,[1] was chosen.

On this basis the chemical composition of the rock was calculated to be that given in column I. This was done before chemical analyses of the rock were made, and the result is of great interest as showing how far this method of estimation may be relied on in favorable cases. If the microscopical measurements had been made to include the magnetite and zircon, the result would have been still more elaborate. Subsequently Analysis II was made by Mr. S. H. Worrell, of the University of Texas Mineral Survey, on a sample of the rock from the land of Mr. H. C. Harned, near Llano, Tex. As the alkalies were not separately determined in this analysis, Dr. H. S. Washington very generously undertook to analyze material from the specimen studied microscopically. The result is given in Analysis III. From

	I	II	III	IV
SiO_2	74.52	74.9	75.90	74.80
Al_2O_3	11.58	11.1	12.07	11.44
Fe_2O_3	0.69	1.6	1.01	1.07
FeO	2.61	1.5	1.45	1.62
MgO	none	.....	0.22	0.28
CaO	0.82	0.2	0.65	0.80
Na_2O	3.40	8.5	3.08	3.32
K_2O	5.46	tr.	5.32	5.52
H_2O+ } H_2O- }	0.36	0.3	0.41 } 0.06 }	0.23
TiO_2	0.29	0.5	0.38	0.40
P_2O_5	0.05	.....	0.15	0.05
F	0.49	.....	n. d.	0.49
CO_2	.....	.....	none	.....
MnO	0.02	1.9	n. d.	0.18
	100.29 less 0.21	100.4	100.70	100.20 less 0.21
	100.08			99 99

[1] See Table XIV in *Quantitative Classification of Igneous Rocks* (Chicago, 1903), mica analysis *e*.

these analyses it will be seen how close the microscopically estimated chemical composition is to that determined by chemical analysis.

The higher silica in III shows that the quartz in the rock was underestimated by 1.5 per cent., or that the piece analyzed by Dr. Washington was slightly richer in quartz phenocrysts.

The following data were determined in the laboratory of the Mineral Survey of the University of Texas: Specific gravity, 2.64; corrected, 2.67. One cubic foot of the rock absorbs 9.47 ounces of water. Crushing strength, 15,300 pounds per square inch of surface.

The alkalies in I and III are remarkably concordant, proving that the determination of the feldspars by optical means was correct; The lime determined in III corresponds to that estimated optically in fluorite and apatite. Fluorine appears only in Analysis I, and is very nearly correct, probably as much so as if determined by chemical means.

The correspondence between the two oxides of iron in both chemical analyses, II and III, the discrepancy in Anlaysis I, and the presence of a small amount of magnesia in III show that the mica analysis chosen from the Cape Ann rock is not the proper composition for the mica in the porphyry under investigation. The probable composition of this mica may be found by subtracting from Analysis III the chemical constituents of the known minerals—quartz, feldspar, fluorite, and apatite—and reckoning the remainder as mica and the extra quartz already mentioned. The result is as follows: extra quartz, 1.37 per cent.; mica, 8.6 per cent., having the composition (*a*).

	(*a*)	(*b*)		(*a*)	(*b*)
SiO_2	32.1	35.26	K_2O	6.8	9.20
Al_2O_3	19.2	10.24	H_2O	5.5	2.71
Fe_2O_3	11.7	12.47	TiO_2	4.4	4.68
FeO	16.8	18.84	MnO	.....	2.14
MgO	2.5	3.24		99.8	99.34
CaO	0.8	0.05			
Na_2O	.....	0.60			

This is approximately the composition of a lepidomelane like that in the nephelite-syenite (*grano-nordmarkose*) of Litchfield, Me.,[1]

[1] *Loc. cit.*, mica analysis *f*.

with a slight difference in the oxides of iron, and a notable amount of titanium oxide. It closely resembles the analysis (*b*) of lepidomelane from nephelite-syenite from the neighborhood of Langesundfjord, Norway, by Scheerer.[1] If this analysis of mica is used in the calculation of the chemical composition of the rock, the result is that given under IV.

The mica is clearly a lepidomelane rich in iron and alumina and poor in magnesia. When a greater variety of micas has been separated from igneous rocks and carefully described and analyzed, it will be possible to estimate the chemical composition of a rock from a microscopical investigation with greater accuracy.

The rock from near Llano, Tex., may be called a quartz-feldspar-porphyry having the composition of a granite. In the "Quantitative System of Classification" it is a graniphyro-liparose-alaskose.

The norm calculated from Dr. Washington's analysis, III, with the addition of fluorine determined microscopically from fluorite is given below under (1). The norm calculated from the mode by means of estimated Analysis IV is given under (2):

	(1) Norm	(2) Norm from Mode	Mode
Quartz	36.90	33.30	34.6
Orthoclase	31.14	32.80	27.8
Albite	26.20	27.77	27.9
Corundum	1.33	.....	....
Hypersthene	1.69	2.42	Biotite 8.6
Magnetite	1.39	1.62	tr.
Ilmenite	0.76	0.76	tr.
Apatite	0.34	tr.	0.13
Fluorite	0.70	1.00	1.00
	100.45	99.67	100.03

The rock is a persalane with about 5 per cent. of femic components. Following the norm from Dr. Washington's analysis, the quartz is so abundant that it is quarfelic, columbare, near the quardofelic order britannare. It is therefore a britannare-columbare. It is peralkalic of the most extreme kind, having no anorthite feldspar, the lime being entirely femic, in fluorite and apatite. It is alaskase near liparase, a liparase-alaskase. And with respect to

[1] See W. C. BRÖGGER, *Zeitschr. Kryst. Min.*, Vol. XVI (1890), p. 191.

alkalies it is sodipotassic, and hence an alaskose near liparose: *liparose-alaskose.* If the norm derived from the mode were made a basis of classification, the rock would be quardofelic, a britannare, near columbare. From this it is evident that the rock is intermediate between these orders, and may be a liparose-alaskose, or an alaskose-liparose.

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